ELECTRICAL II

COURSE DESCRIPTION

***Electrical II* is a course in which students will learn and practice intermediate skills related to electrical systems, with emphasis on commercial systems. Topics covered include over-current protection; sizing conductors; lighting systems; three-phase motors; motor control circuits; sizing raceways, boxes, and fittings; and connecting distribution transformers, including a laboratory experience conducted in a shop environment that supports electrical assembly projects by students. This course gives students a substantial skill and knowledge foundation typically required for apprentice electricians.**

Prerequisite(s):	Electrical I, Algebra I or Math for Technology II Geometry, Principles of Technology I or Physical Science (may be concurrent)
Recommended Credits:	2
Recommended Grade Level(s):	12^{th}

ELECTRICAL II STANDARDS

1.0 Students will demonstrate leadership, citizenship, and teamwork skills required for success in the school, community, and workplace.

2.0 Students will assume responsibility for the safety of themselves, their coworkers, and bystanders.

3.0 Students will interpret, lay out, and fabricate in conformance to construction drawings and written specifications.

4.0 Students will use safe practices when working with electrical systems.

5.0 Students will analyze and install over-current protective devices, such as fuses and circuit breakers.

6.0 Students will select and install appropriate lighting fixtures for common applications.

7.0 Students will calculate load and required conductor size and over-current protection for branch circuits.

8.0 Students will analyze and properly employ over-current protection devices.

9.0 Students will analyze, install, and troubleshoot lighting systems.

10.0 Students will install three-phase motors and control circuits.

11.0 Students will describe, install, and troubleshoot electrical circuits associated with heating, ventilation, and air conditioning (HVAC) equipment.

12.0 Students will size raceways, boxes, and fittings based on fill and bend requirements.

13.0 Students will determine type and location of electrical switches and receptacles.

14.0 Students will select, connect, and test distribution system transformers.

15.0 Students will analyze the theory of electric motors and install motors in accordance with industry requirements.

16.0 Students will construct and design motor control circuits.

17.0 Students will assess hazardous locations and possible sources of ignition.

ELECTRICAL II

STANDARD 1.0

Students will demonstrate leadership, citizenship, and teamwork skills required for success in the school, community, and workplace.

LEARNING EXPECTATIONS

The student will:

1.1 Demonstrate leadership skills.
1.2 Use problem-solving techniques to address and propose solutions to school, community, and workplace problems.
1.3 Demonstrate the ability to work professionally with others.
1.4 Participate in SkillsUSA-VICA as an integral part of instruction.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:

1.1.A Exhibits integrity and pride in workmanship.
1.1.B Keeps group work focused on task.
1.2.A Determines the root causes of observed conflicts or problems.
1.2.B Mediates disputes between parties.
1.3.A Participates in a job shadowing experience.
1.3.B Assembles a student team to solve an assigned problem.
1.4.A Attends and participates in periodic meetings of SkillsUSA-VICA or similar organization.

SAMPLE PERFORMANCE TASKS

- Prepare a resume.
- Participate in various SkillsUSA-VICA or similar programs and/or competitive events.
- Attend a professional organization meeting such as, local Chamber of Commerce meeting.
- Participate in the American Spirit Award competition with SkillsUSA-VICA.
- Participate in job shadowing or internship program with local business or industry.
- Take an active role in a group project assigned by the instructor.
- Identify and detail a problem area in the school, community, or workplace, and propose solutions. If possible, and with appropriate approvals, implement or facilitate the solution.

INTEGRATION LINKAGES

SkillsUSA-VICA, *Professional Development Program,* SkillsUSA-VICA, Communications and Writing Skills, Teambuilding Skills, Research, Language Arts, Sociology, Psychology, Algebra, Geometry, Applied Communication, Algebra, Geometry, Social Studies, Problem Solving, Interpersonal Skills, Employability Skills, Critical-Thinking Skills, SCANS (Secretary's Commission on Achieving Necessary Skills), Chamber of Commerce, Colleges, Universities, Technology Centers, and Employment Agencies

ELECTRICAL II

STANDARD 2.0

Students will assume responsibility for the safety of themselves, their coworkers, and bystanders.

LEARNING EXPECTATIONS

The student will:

2.1 Exhibit and encourage in others a positive attitude regarding safety practices and issues.
2.2 Habitually inspect and use appropriate personal protective equipment for assigned tasks.
2.3 Inspect, maintain, and employ safe operating procedures with tools and equipment, such as electrical test equipment, lifting equipment, powder actuated drivers, and high pressure gas containers.
2.4 Exhibit a well-developed awareness of potential hazards to themselves and others.
2.5 Carry out responsibilities under Hazard Communication (HazCom) regulations.
2.6 Take action to protect coworkers and bystanders from hazards as required by regulations, and company policies.
2.7 Report accidents and observed hazards, and execute emergency response procedures as required by regulations, and company policies.
2.8 Demonstrate appropriate related safety procedures.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:

2.1.A Includes safety procedures in activity plans.
2.1.B Exhibits an awareness of proper safety procedures by coworkers.
2.1.C Responds positively to instruction, advice, and correction regarding safety issues.
2.1.D Reports to school or work physically ready to perform to professional standards, such as rested, or not impaired by medications, drugs, alcohol, and so forth.
2.2.A Selects, inspects, and uses the correct personal protective equipment for the assigned task.
2.3.A Uses disconnect switches and lockout/tagout proceedures.
2.3.B Inspects extension cords for the presence of a functional ground connection, prior to use.
2.4.A Observes personnel and activities in the vicinity of their work area.
2.4.B Warns nearby personnel, prior to starting potentially hazardous actions.
2.5.A Applies information from material safety data sheets (MSDSs) to protect self and others from the health hazards associated with assigned tasks.
2.5.B Reports hazards found on the job site to their supervisor and remedies the hazard as instructed.
2.6.A Anticipates and warns bystanders when using air and powder actuated drivers.
2.6.B Provides and activates adequate ventilation equipment as required by the task.
2.7.A Reports all injuries and observed unguarded hazards to the immediate supervisor.
2.7.B Executes assigned tasks as described in emergency response procedures.
2.8.A Passes with 100 % accuracy a written examination relating to safety issues.
2.8.B Passes with 100% accuracy a performance examination relating to safety.
2.8.C Maintains a portfolio record of written safety examinations and equipment examinations for which the student has passed an operational checkout by the instructor.

SAMPLE PERFORMANCE TASKS

- Prior to assigning a task using power tools, the instructor removes some required safety items and instructs students to perform an inspection of tools.
- Instruct a visitor to obviously approach the vicinity of a student conducting a hazardous activity and note the level of awareness demonstrated by the student.
- In a project requiring solvents or adhesives, introduce a new brand or type and require students to retrieve the MSDS and identify possible health hazards.

INTEGRATION LINKAGES

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, Applied Communication, Algebra, Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA-VICA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), National Center for Construction Education and Research (NCCER), Occupational Safety and Health Administration (OSHA), Environmental Protection Agency (EPA), United States Department of Labor, Tennessee Department of Labor and Workforce Development, NCCER, International Brotherhood of Electrical Workers (IBEW)

ELECTRICAL II

STANDARD 3.0

Students will interpret, lay out, and fabricate in conformance to construction drawings and written specifications.

LEARNING EXPECTATIONS

The student will:

3.1 Scale dimensions that are not explicitly included in construction drawings.
3.2 Interpret plan and elevation views shown in construction drawings.
3.3 Recognize and interpret lines and symbols commonly used in construction drawings.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:

3.1.A Uses the scale of a drawing to determine locations not explicitly dimensioned.
3.1.B Uses the scale of a drawing to determine dimensions not explicitly shown on drawing.
3.2.A Interprets three-dimensional features found in construction drawings.
3.3.A Readily relates electrical components and nodes with symbolic components and nodes in electrical schematics and ladder diagrams.
3.3.B Readily relates physical components and connections in HVAC control systems with symbolic components and nodes in HVAC control schematics and ladder diagrams.

SAMPLE PERFORMANCE TASKS

- Given a set of plans and specifications for a residential or commercial structure, make a complete material take-off for the electrical service.
- Given a set of plans and specifications for a residential or commercial structure, determine the location of electrical elements not explicitly dimensioned.
- Determine the detail of specified routing and structural supports for conduit runs shown in construction drawings.
- Given electrical schematics or ladder diagrams for an existing polyphase motor control system, perform a series of diagnostic voltage measurements at teacher-designated locations on the schematic or diagram.
- Given a set of plans and specifications for a residential or commercial structure, make a complete material for electrical rough-in.

INTEGRATION LINKAGES

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, Applied Communication, Algebra, Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA-VICA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), National Center for Construction Education and Research (NCCER), Occupational Safety and Health Administration (OSHA), Environmental Protection Agency, United States Department of Labor, Tennessee Department of Labor and Workforce Development, NCCER, International Brotherhood of Electrical Workers

ELECTRICAL II

STANDARD 4.0

Students will use safe practices when working with electrical systems.

LEARNING EXPECTATIONS

The student will:

4.1 Demonstrate the use of protective equipment and tools on high voltage systems (over 600 V), real or mock-up.
4.2 Evaluate the burn and blast hazards associated with large battery systems.
4.3 Research the environmental hazards associated with oil-filled transformers.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student, when given an assigned task:

4.1.A Demonstrates the care and use of glove systems associated with high-voltage electrical work.
4.1.B Demonstrates use of hot-stick to replace fuses on distribution transformers.
4.2.A Estimates the possible maximum current resulting from an accidental short across large battery systems.
4.2.B Calculates the rate of heat generation from the above current and voltage estimates.
4.2.C Compiles a list of protective equipment needed when working on large battery systems.
4.2.D Describes measures to mitigate the risks associated with electrolytes and evolved gases from battery systems.
4.3.A Researches the material safety data sheets (MSDSs) covering various transformer oils.
4.3.B Writes a report detailing measures to properly handle transformer oils.

SAMPLE PERFORMANCE TASKS

- Write a procedure for replacing a defective battery in a large battery installation.
- Demonstrate the procedure to connect a mock-up distribution transformer to an energized feeder, using proper tools and protective equipment.
- Write a report on local options to dispose of used transformer oil.

INTEGRATION LINKAGES

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, Applied Communication, Algebra, Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA-VICA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), National Center for Construction Education and Research (NCCER), Occupational Safety and Health Administration (OSHA), Environmental Protection Agency, United States Department of Labor, Tennessee Department of Labor and Workforce Development, NCCER, International Brotherhood of Electrical Workers

ELECTRICAL II

STANDARD 5.0

Students will analyze and install over-current protective devices, such as fuses and circuit breakers.

LEARNING EXPECTATIONS

The student will:

5.1 Compare the characteristics and uses of fuses and circuit breakers.
5.2 Identify physical examples of fuses and circuit breakers.
5.3 Demonstrate the installation, wiring, testing, and operation of fuses and breakers in both single and polyphase circuits.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:

5.1.A Justifies a specific choice of fuse or circuit breaker for over-current protection.
5.2.A Determines characteristics of a fuse needing replacement based on markings printed on the fuse.
5.2.B Classifies a circuit breaker by its voltage, current, and interrupting-capacity ratings by physical observation or reference to technical manuals.
5.3.A Installs, connects, and tests fuses.
5.3.B Installs, connects, and tests circuit breakers.

SAMPLE PERFORMANCE TASKS

- Install and test breakers for residential service or mockup.
- Remove, test for continuity, and reinstall fuses in polyphase disconnect switches.

INTEGRATION LINKAGES

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, Applied Communication, Algebra, Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA-VICA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), National Center for Construction Education and Research (NCCER), Occupational Safety and Health Administration (OSHA), Environmental Protection Agency, United States Department of Labor, Tennessee Department of Labor and Workforce Development, NCCER, International Brotherhood of Electrical Workers

ELECTRICAL II

STANDARD 6.0

Students will select and install appropriate lighting fixtures for common applications.

LEARNING EXPECTATIONS

The student will:

6.1 Compare and contrast the characteristics of various types of electrical lights, such as incandescent, fluorescent, and high-intensity discharge.

6.2 Discuss the advantages of various types of electric lights, such as incandescent, fluorescent, and high-intensity discharge in particular applications.

6.3 Demonstrate correct installation and wiring of various types of electric lights, such as incandescent, fluorescent, and high-intensity discharge.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:

6.1.A Compares the modes of operation of the various types of electric lights.

6.1.B Compares the electric efficiencies of the various types of electric lights.

6.1.C Compares the rated average operating life of the various types of electric lights.

6.2.A Selects or recommends appropriate light systems based on suitability of light, such as intensity or color rendering.

6.2.B Selects or recommends appropriate light systems based on initial cost, operating cost, and maintenance requirements.

6.2.C Selects or recommends appropriate light systems based on potential temperature hazards.

6.3.A Installs and wires various types of electric lights.

SAMPLE PERFORMANCE TASKS

- Critique lighting choices as indicated by a residential or commercial blueprint.
- Install incandescent, fluorescent, and high-intensity discharge light fixture in an actual structure or mockup.

INTEGRATION LINKAGES

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, Applied Communication, Algebra, Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA-VICA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), National Center for Construction Education and Research (NCCER), Occupational Safety and Health Administration (OSHA), Environmental Protection Agency, United States Department of Labor, Tennessee Department of Labor and Workforce Development, NCCER, International Brotherhood of Electrical Workers

ELECTRICAL II

STANDARD 7.0

Students will calculate load and required conductor size and over-current protection for branch circuits.

LEARNING EXPECTATIONS

The student will:

7.1 Calculate loads for single-phase and three-phase branch circuits.
7.2 Size branch-circuit over-current protection devices and conductors for non-continuous and continuous-duty circuits.
7.3 Comprehend and apply derating to size branch circuits.
7.4 Locate over-current protection devices based on National Electrical Code (NEC) rules.
7.5 Calculate resistance of conductors.
7.6 Adjust conductor size to compensate for voltage drop.
7.7 Select conductors with properties appropriate to the application.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:

7.1.A Calculates the branch circuit load for a specified residential structure.
7.1.B Calculates the branch circuit load for a specified commercial structure.
7.2.A Selects conductor size and over-current protection for branch circuits in a specified multifamily structure.
7.2.B Selects conductor size and over-current protection for branch circuits in a specified commercial structure.
7.3.A Determines applicable derating factors for branch circuits in a specified multifamily structure.
7.3.B Determines applicable derating factors for branch circuits in a specified commercial structure.
7.4.A Determines the physical location of over-current protection devices for a proposed feeder circuit.
7.5.A Calculates the electrical resistance of a conductor, given material, length, and conductor size.
7.6.A Calculates the expected voltage drop, given details for a proposed circuit involving very long conductor runs and its associated loads.
7.6.B Compares calculated voltage drops to NEC recommendations and recommends changes to the conductor, as needed.
7.7.A Determines acceptable types of conductors based on ampacity, temperature, and environment, given details for a commercial feeder circuit.

SAMPLE PERFORMANCE TASKS

- Given blueprints for an existing common-use laundry area in a multifamily dwelling and the intent to add four 7500 VA dryers, determine the new branch circuit load and required sizes for conductors, over-current protection.
- Given blueprints for a commercial building having a three-phase 480-V service and the intent to replace a 15-ton AC unit with a 20-ton AC unit, determine the new branch circuit load and required sizes for conductors, over-current protection, and conduit.

- For a detailed project to add two transformers for branch circuits, determine the physical location of over-current protection. For example, one transformer might be located close to the service (less than 20 feet), while the second is farther away (more than 100 feet).
- Select conductors to limit voltage drop to less than 1% of the supply voltage to a specific sump pump located 300 feet away.
- Adjust conductor choice for the sump pump above if the conduit carrying the conductors must pass through a boiler room where ambient temperature can reach 110°F.

INTEGRATION LINKAGES

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, Applied Communication, Algebra, Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA-VICA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), National Center for Construction Education and Research (NCCER), Occupational Safety and Health Administration (OSHA), Environmental Protection Agency, United States Department of Labor, Tennessee Department of Labor and Workforce Development, NCCER, International Brotherhood of Electrical Workers

ELECTRICAL II

STANDARD 8.0

Students will analyze and properly employ over-current protection devices.

LEARNING EXPECTATIONS

The student will:

8.1 Distinguish between overload and short-circuit current.
8.2 Distinguish between current rating and interrupting capacity of a breaker or fuse.
8.3 Choose an over-current protection device or combination of devices adequate to protect circuit components.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:

8.1.A Describes situations where overload conditions may be normal.
8.1.B Compares and contrasts the difference between fast-acting fuses and current limiting devices for short circuit protection.
8.2.A Compares and contrasts current rating and interrupting capacity of a breaker or fuse.
8.3.A Makes appropriate choices for over-current and short-circuit protection devices for a given circuit.

SAMPLE PERFORMANCE TASKS

- Monitor transient currents during motor startup (e.g., large grinding wheel), noting the ratio of peak starting current to normal operating current.
- Using motor circuit above, verify tolerance of slow acting fuses during startup compared to fast-acting fuses.

INTEGRATION LINKAGES

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, Applied Communication, Algebra, Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA-VICA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), National Center for Construction Education and Research (NCCER), Occupational Safety and Health Administration (OSHA), Environmental Protection Agency, United States Department of Labor, Tennessee Department of Labor and Workforce Development, NCCER, International Brotherhood of Electrical Workers

ELECTRICAL II

STANDARD 9.0

Students will analyze, install, and troubleshoot lighting systems.

LEARNING EXPECTATIONS

The student will:

9.1 Distinguish between incandescent, fluorescent, and high-intensity discharge (HID) and describe how each operates.
9.2 Compare and contrast the advantages and disadvantages of incandescent, fluorescent, and HID lighting systems.
9.3 Install and wire incandescent, fluorescent, and HID lighting systems.
9.4 Troubleshoot fluorescent and HID lighting systems.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:

9.1.A Compares and contrasts the operational characteristics of incandescent, fluorescent, and high-intensity discharge (HID) lighting systems.
9.2.A Selects a lighting system (incandescent, fluorescent, or HID) for a specified application, using criteria such as initial cost, operating cost, and maintenance cost.
9.3.A Installs fluorescent light fixtures in a commercial environment or mock-up.
9.3.B Installs HID light fixtures in a commercial environment or mock-up.
9.4.A Devises and uses a troubleshooting checklist to verify operation of fluorescent and HID lighting systems.

SAMPLE PERFORMANCE TASKS

- Measure normal operating voltage and current associated with incandescent, fluorescent, and HID lighting systems having approximately equivalent light output.
- Include incandescent, fluorescent, and HID lighting fixtures in a mockup a commercial three-phase electrical system.

INTEGRATION LINKAGES

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, Applied Communication, Algebra, Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA-VICA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), National Center for Construction Education and Research (NCCER), Occupational Safety and Health Administration (OSHA), Environmental Protection Agency, United States Department of Labor, Tennessee Department of Labor and Workforce Development, NCCER, International Brotherhood of Electrical Workers

ELECTRICAL II

STANDARD 10.0

Students will install three-phase motors and control circuits.

LEARNING EXPECTATIONS

The student will:

10.1 Size, select, and install overload relays for electric motors.
10.2 Calculate and install devices to improve the power factor at motor locations.
10.3 Install dual-voltage three-phase motors.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:

10.1.A Installs wire overload relays associated with motor contactors in motor control circuits.
10.2.A Determines the correct size and proper placement in the circuit of capacitors for power factor correction based on a description of a motor.
10.3.A Connects dual-voltage three-phase motors in their low- and high-voltage configurations.
10.3.B Measures operating current in low- and high-voltage configurations of dual-voltage three-phase motors.

SAMPLE PERFORMANCE TASKS

- Select all components, install, and wire a three-phase reversing motor-control circuit, including overload relays.
- For the motor control circuit above, determine the proper size and optimum location for connecting capacitors for power-factor correction.
- Measure and compare the operating current of a dual-voltage three-phase motor when connected to 240V versus 440V.

INTEGRATION LINKAGES

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, Applied Communication, Algebra, Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA-VICA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), National Center for Construction Education and Research (NCCER), Occupational Safety and Health Administration (OSHA), Environmental Protection Agency (EPA), United States Department of Labor, Tennessee Department of Labor and Workforce Development, International Brotherhood of Electrical Workers (IBEW)

ELECTRICAL II

STANDARD 11.0

Students will describe, install, and troubleshoot electrical circuits associated with heating, ventilation, and air conditioning (HVAC) equipment.

LEARNING EXPECTATIONS

The student will:

11.1 Compare the various types of heating systems used in residential and commercial applications.
11.2 Interpret electrical nameplate data on HVAC equipment.
11.3 Install electrical circuits and related components to HVAC equipment in accord with National Electrical Code (NEC).
11.4 Troubleshoot electrical components of HVAC systems.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:

11.1.A Describes the physical and electrical configuration of baseboard heaters, wall and kick-space mounted heaters, electric furnaces, and radiant floor and ceiling systems.
11.1.B Explains the operation of thermostats, limit controls, and time-delay relays as control elements in HVAC systems.
11.2.A Determines the operating voltage, full-load current, and lock-rotor current values from the nameplate data on HVAC systems,.
11.2.B Determines NEC requirements for motor control and protection for a specific HVAC compressor based on nameplate data and other factors.
11.3.A Determines NEC requirements for motor control and protection for a specific HVAC compressor based on nameplate data and other factors.
11.3.B Determines lighting and convenience receptacles required by NEC for a given HVAC installation.
11.3.C Completes the electrical wiring associated with an HVAC installation.
11.4.A Devises and completes a troubleshooting checklist for the electrical components of an HVAC system.

SAMPLE PERFORMANCE TASKS

- From the nameplate data on HVAC systems and NEC requirements, determine the required feeder size, disconnect devices, and external motor controls.
- From blueprints detailing a residential electrical heating system, determine the required electrical feeder and control devices.
- For the electrical heating system above, devise a checklist for verifying operation after initial installation.

INTEGRATION LINKAGES

Science; Language Arts; Communication; Algebra; Geometry; Computer, Research, Writing, Leadership, and Teamwork Skills; SCANS; SkillsUSA-VICA; ABC; AGC; NCCER; OSHA; EPA; US and Tenn. Departments of Labor, IBEW; NCCER 26312

ELECTRICAL II

STANDARD 12.0

Students will size raceways, boxes, and fittings based on fill and bend requirements.

LEARNING EXPECTATIONS

The student will:

12.1 Size and install raceways, pull boxes, outlet boxes, and junction boxes in accordance with National Electrical Code (NEC) requirements for conductor bend radius and raceway fill limitations.

12.2 Size and install raceways, pull boxes, outlet boxes, and junction boxes to facilitate practical conductor installation, splicing, and terminations.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:

12.1.A Sizes raceways, pull boxes, outlet boxes, and junction boxes in accordance with NEC requirements for conductor bend radius and raceway fill limitations, given a proposed additional feeder circuit.

12.1.B Installs the raceways, boxes, and conductors, and completes required splices and terminations for the above project.

12.2.A Sizes raceways, pull boxes, outlet boxes, and junction boxes to facilitate practical conductor installation, splicing, and terminations, given a proposed additional feeder circuit.

12.2.B Installs the raceways, boxes, and conductors, and completes required splices and terminations for the above project.

SAMPLE PERFORMANCE TASKS

- Determine the conduit run required to supply a feeder circuit for a proposed 20-ton AC unit for the school. Students will be expected to determine details such as the route and size of conduit, pull boxes, junction boxes, disconnects, and so forth based on their survey or blueprint analysis of the building. Factors to consider can include practicality, cost, aesthetics, etc.

INTEGRATION LINKAGES

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, Applied Communication, Algebra, Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA-VICA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), National Center for Construction Education and Research (NCCER), Occupational Safety and Health Administration (OSHA), Environmental Protection Agency, United States Department of Labor, Tennessee Department of Labor and Workforce Development, NCCER, International Brotherhood of Electrical Workers

ELECTRICAL II

STANDARD 13.0

Students will determine type and location of electrical switches and receptacles.

LEARNING EXPECTATIONS

The student will:

13.1 Determine type and location of electrical receptacles, as appropriate for use and required by National Electrical Code (NEC).

13.2 Determine type and location of electrical switches, as appropriate for use and required by NEC.

Note: Installing of switches and receptacles has been covered in a previous course. The instructor may optionally choose to include some installation practice here.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:

13.1.A Selects the proper type of electrical receptacles, based on usage and required voltage and current ratings.

13.1.B Selects the proper location for electrical receptacles, based on intended use and NEC requirements.

13.2.A Selects the proper type of electrical switches, based on usage and required voltage and current ratings.

13.2.B Selects the proper location for electrical switches, based on intended use and NEC requirements.

SAMPLE PERFORMANCE TASKS

- Given a floor plan for a single-family residence, determine type and location of switches and receptacles, as reasonable for use and required by NEC.
- For the residential project above, create a switch and receptacle bill of materials.

INTEGRATION LINKAGES

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, Applied Communication, Algebra, Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA-VICA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), National Center for Construction Education and Research (NCCER), Occupational Safety and Health Administration (OSHA), Environmental Protection Agency, United States Department of Labor, Tennessee Department of Labor and Workforce Development, NCCER, International Brotherhood of Electrical Workers

ELECTRICAL II

STANDARD 14.0

Students will select, connect, and test distribution system transformers.

Note: All transformer connections in this course will be made as voltage-scaled models. The high voltage windings of transformers used will not exceed 240 V. Low voltage windings will typically be in the 6V to 24V range. The facility should be equipped to provide three-phase 120/240V power, or similar.

LEARNING EXPECTATIONS

The student will:

14.1 Describe basic transformer construction and operation.
14.2 Connect a multi-tap single-phase transformer for required secondary voltage(s).
14.3 Connect transformers in both star- and delta-configurations to provide low-voltage three-phase power.
14.4 Connect transformers to provide star to delta transformations.
14.5 Determine transformer sizes for various kVA loads.
14.6 Test transformers.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:

14.1.A Describes the three basic components of a distribution transformer.
14.1.B Describes relationship between input and output voltage, current, and turns ratio.
14.2.A Connects a multi-tap single-phase transformer to obtain specified output voltage for a given input voltage, and verify by voltage measurements.
14.3.A Connects transformers in a star-configuration to provide a specified star-connected output, and verify proper phase connections by voltage measurements.
14.3.B Connects transformers in a delta-configuration to provide a specified delta-connected output, and verify proper phase connections by voltage measurements.
14.4.A Connects transformers to provide a three-phase step-down in a star-to-delta transformation, and verify proper phase connections by voltage measurements.
14.5.A Assesses size, input and output voltages, and installation environment for proposed transformer application.
14.5.B Selects appropriate transformer for a given load and installation.
14.6.A Tests transformers for open circuits and windings, ground faults, and no-load voltage ratios.

SAMPLE PERFORMANCE TASKS

- Test all transformers in the shop for open windings, ground faults, and determine their no-load voltage ratios.
- Select two transformers whose secondaries have the same voltage rating, connect their secondaries. Apply input voltage to the primary of one transformer and an appropriate load to the primary of the second transformer. Measure the voltage and current through the windings of each transformer.
- Repeat the above project using three-phase transformers, making at least one star-to-delta transformation.

INTEGRATION LINKAGES

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, Applied Communication, Algebra, Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA-VICA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), National Center for Construction Education and Research (NCCER), Occupational Safety and Health Administration (OSHA), Environmental Protection Agency, United States Department of Labor, Tennessee Department of Labor and Workforce Development, NCCER, International Brotherhood of Electrical Workers

ELECTRICAL II

STANDARD 15.0

Students will analyze the theory of electric motors and install motors in accordance with industry requirements.

LEARNING EXPECTATIONS

The student will:

15.1 Select and identify a motor based on its intended use.

15.2 Determine the installation requirements to satisfy National Electrical Code (NEC) and OSHA regulations, given a motor and specified application.

15.3 Select, install, and wire DC, single-phase, and polyphase electric motors.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:

15.1.A Given an application, determines the size, speed, operating voltage, and National Electrical Manufacturing Association (NEMA) type for the required motor.

15.1.B Identifies and properly selects a motor based upon the intended use and NEMA enclosure classification.

15.2.A Determines the required over-current protection, motor control circuits, conductor types and sizes, and conduit types and sizes, as required by NEC, OSHA regulations and described by installation drawings for a given motor and application.

15.3.A Comprehends basic operation of DC motors and common, single phase AC motors, and three-phase induction motors.

15.3.B Distinguishes between and contrast the operating characteristics of series and shunt DC motors.

15.3.C Contrasts and compares starting procedures and circuits for split-phase induction motors and capacitor-type induction motors.

15.3.D Selects, installs, and properly wires three-phase induction motors with the necessary motor contactors, overload protection, and control switches.

SAMPLE PERFORMANCE TASKS

- Given an application requiring a DC motor (other than a permanent magnet motor), select, install, and wire the motor in accordance with installation needs and NEC and OSHA requirements.
- Given an application requiring a single-phase capacitor motor, select, install, and wire the motor in accordance with installation needs and NEC and OSHA requirements.
- Given an application requiring a reversing three-phase motor, select, install, and wire the motor in accordance with installation needs and NEC and OSHA requirements.

INTEGRATION LINKAGES

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, Applied Communication, Algebra, Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA-VICA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), National Center for Construction Education and Research (NCCER), Occupational Safety and Health Administration (OSHA), Environmental Protection Agency, United States Department of Labor, Tennessee Department of Labor and Workforce Development, NCCER, International Brotherhood of Electrical Workers

ELECTRICAL II

STANDARD 16.0

Students will construct and design motor control circuits.

LEARNING EXPECTATIONS

The student will:

16.1 Construct motor control circuits for a single-phase motor.
16.2 Construct motor control circuits for a poly-phase motor.
16.3 Design motor control circuits for three-phase motors.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:

16.1.A Constructs a motor control circuit for a fractional horsepower motor, given a wiring diagram or ladder diagram.
16.1.B Constructs a motor control circuit for an integral horsepower single-phase motor, given a wiring diagram or ladder diagram.
16.2.A Constructs a motor control circuit for a three-phase motor using magnetic controllers that include over-load relays, given a wiring diagram or ladder diagram.
16.2.B Constructs a three-pole reversing starter with overload protection, or a starter that provides reduced-voltage starting capability, such as a resistance starter for a squirrel-cage induction motor, given a wiring diagram or ladder diagram.
16.3.A Produces wiring and ladder diagrams, given a list of required control functions for an application.

SAMPLE PERFORMANCE TASKS

- Construct a motor control circuit for a single-phase integral horsepower application, such as a milling machine spindle drive.
- Construct a motor-control circuit for a three-phase reversing motor, such as a bi-directional conveyor motor.
- Given a statement of required control functions for an industrial application, such as start, stop, limit switches, etc., produce wiring and ladder diagrams that the provide specified functions, over-current and overload protection, and other functions as required by NEC.

INTEGRATION LINKAGES

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, Applied Communication, Algebra, Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA-VICA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), National Center for Construction Education and Research (NCCER), Occupational Safety and Health Administration (OSHA), Environmental Protection Agency, United States Department of Labor, Tennessee Department of Labor and Workforce Development, NCCER, International Brotherhood of Electrical Workers

ELECTRICAL II

STANDARD 17.0

Students will assess hazardous locations and possible sources of ignition.

LEARNING EXPECTATIONS

The student will:

17.1 Assess hazardous locations.
17.2 Assess possible sources of ignition.

PERFORMANCE STANDARDS: EVIDENCE STANDARD IS MET

The student:

17.1.A Evaluates the possible presence of easily ignitable fibers or airborne materials, such as wood or fabric particles, and recognizes these materials as a hazard.
17.1.B Evaluates the possible presence of suspended, combustible dust, such as flour or coal dust, and recognizes these materials as a hazard.
17.1.C Evaluates the possible presence of volatile, flammable gases, vapors, or liquids, and recognizes these materials as a hazard.
17.2.A Evaluates possible electrical ignition sources such as switches, circuit breakers, motor starters, and relays, and recognizes these items as a hazard.
17.2.B Evaluates possible non-electrical ignition sources, such as steel hand tools and friction-heated tools (e.g., drill bits, grinders), and recognizes these items as a hazard.

SAMPLE PERFORMANCE TASKS

- Participates in class field trips to local industries having examples of various classifications of hazardous locations, such as coal mines, hospitals, airports, grain elevators, lumber mills.
- Conducts Internet research of past major industrial explosions and fires.
- Participates in a fire department presentation/demonstration of hazardous locations.

INTEGRATION LINKAGES

Science, Computer Skills, Research and Writing Skills, Language Arts, Communication Skills, Leadership Skills, Teamwork Skills, Applied Communication, Algebra, Geometry, Secretary's Commission on Achieving Necessary Skills (SCANS), SkillsUSA-VICA, Associated Builders and Contractors (ABC), Associated General Contractors (AGC), National Center for Construction Education and Research (NCCER), Occupational Safety and Health Administration (OSHA), Environmental Protection Agency, United States Department of Labor, Tennessee Department of Labor and Workforce Development, NCCER, International Brotherhood of Electrical Workers

ELECTRICAL II

SAMPLING OF AVAILABLE RESOURCES

- National Center for Construction Education and Research (NCCER), *Core Curriculum*. Prentice Hall, Upper Saddle River, NJ; ©2000. Also known as the "Wheels of Learning" materials.
- National Center for Construction Education and Research (NCCER), *Electrical Level One*. Prentice Hall, Upper Saddle River, NJ; ©2000. Also known as the "Wheels of Learning" materials.
- National Center for Construction Education and Research (NCCER), *Electrical Level Two*. Prentice Hall, Upper Saddle River, NJ; ©2000. Also known as the "Wheels of Learning" materials.
- National Center for Construction Education and Research (NCCER), *Electrical Level Three*. Prentice Hall, Upper Saddle River, NJ; ©1999. Also known as the "Wheels of Learning" materials.
- National Center for Construction Education and Research (NCCER), *Electrical Level Four*. Prentice Hall, Upper Saddle River, NJ; ©1999. Also known as the "Wheels of Learning" materials.